

Contribution to the knowledge of *Tetraleurodes* Cockerell (Hemiptera: Aleyrodidae) in China

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Abstract: Five species in the genus *Tetraleurodes* Cockerell (Hemiptera: Aleyrodidae) known to occur in China were studied. *Tetraleurodes thenmozhaiae* Jesudasan and David is recognized as a newly recorded species to China and is redescribed with morphological illustrations and photographs taken with a scanning electron microscope (SEM). Comments on the other four species, *T. acaciae* (Quaintance), *T. neemani* Bink-Moenen, *T. graminis* Takahashi and *T. oplismeni* Takahashi are provided. An identification key to the puparia of Chinese *Tetraleurodes* species is given. Specimens are deposited in the Insect Collection of Zhejiang Agriculture & Forestry University, Hangzhou, China.

Key words: Aleyrodidae; *Tetraleurodes*; taxonomy; new record

中国草粉虱属 *Tetraleurodes* Cockerell 分类研究（半翅目：粉虱科）

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摘要: 对中国粉虱科草粉虱属 *Tetraleurodes* 种类进行了分类研究。记述了中国新记录种: *Tetraleurodes thenmozhaiae* Jesudasan and David, 对其进行了重新描述, 并提供了其鉴别特征, 分布, 寄主植物及形态图片。对中国分布的另外 4 种草粉虱即刺桐草粉虱 *T. acaciae* (Quaintance), 纽曼草粉虱 *T. neemani* Bink-Moenen, 禾草粉虱 *T. graminis* Takahashi, 球米草粉虱 *T. oplismeni* Takahashi 进行了简单讨论。以伪蛹特征编制了中国草粉虱属种类的分类检索表。

关键词: 粉虱科; 草粉虱属; 分类; 新记录

Introduction

The whitefly genus *Tetraleurodes* was erected by Cockerell (1902) with *Tetraleurodes perileuca* Cockerell, 1902 as its type species by original designation. This genus currently includes 72 species worldwide (Nakahara 1995; Martin & Mound 2007; Sundararaj & Pushpa 2009; Dubey & Ramamurthy 2015; Sanchez-Flores *et al.* 2017), whose genus members feed on a wide range of host plants. *Tetraleurodes* species commonly feed on monocot as well as dicot plants. Nakahara (1995) reviewed the *Tetraleurodes* species from

North America, described ten new species and proposed the *T. acaciae* group which consists of seven species all having tubercles along the submargin of the puparium. Dubey and Ramamurthy (2015) provided a key to nine grass-feeding (Poaceae) *Tetraleurode* species from all over the world. Currently, only 4 species of the genus have been recorded from China. Dubey and Ko (2008) reported three species, *T. acaciae* (Quaintance), *T. graminis* Takahashi and *T. oplismeni* Takahashi from Taiwan. They redescribed and illustrated the puparia and adults of these three species and also provided the identification keys to puparia and adults of these three species. Martin and Lau (2011) listed two species, *T. acaciae* (Quaintance) and *T. graminis* Takahashi from Hong Kong. Wang *et al.* (2016) recorded *T. neemani* Bink-Moenen from Guangzhou, China. Here, the fifth Chinese species, *Tetraleurodes thenmozhiiae* Jesudasan and David infesting leaves of *Indocalamus tessellatus* (Graminales: Poaceae) leaves from the Zhejiang Jiulong Mountain National Nature Reserve in Zhejiang is recorded and comments on the other four *Tetraleurodes* species known to occur in China are provided.

Material and methods

The puparia of the new record species were collected by Jirui WANG from *Indocalamus tessellatus* in the Zhejiang Jiulong Mountain National Nature Reserve, Zhejiang, China. No adults were collected in the wild, and no adult emergence was noticed during two weeks after the puparia were taken to the lab. The puparia were mounted following the method suggested by Dubey and David (2012). The terminology for morphological structures follows Bink-Moenen (1983), Martin (1985) and Gill (1990). The habitus images were taken using the digital camera Canon IXUS 105 and LEICA M65 C stereo-microscope (Leica, Wetzlar, Germany) attached to a LEICA MC190 HD (Leica, Wetzlar, Germany). Puparial measurements and microphotographs were taken using a Zeiss (Carl Zeiss, Gottingen, Germany) from Zhejiang Agriculture & Forestry University. The scanning electron microscope images were taken by a Philips XL30-Environmental Scanning Electron Microscope (Philips, UK) and Hitachi TM-1000 Scanning Electron Microscope (Hitachi, Japan). Adobe Photoshop software was used to make small adjustments and to assemble the plates.

Taxonomy

Tetraleurodes Cockerell, 1902

Aleurodes (*Tetraleurodes*): Cockerell, 1902: 279. Type species: *Aleyrodes* (*Tetraleurodes*) *perileuca* Cockerell 1902, by original designation.

Diagnosis. Puparia sclerotized, usually black, some species white, or dark brown. Suboval or elongate, margin dentate, strongly toothed, tips rugose, tracheal pore areas usually not differentiated from margin, paired anterior and posterior marginal setae; submarginal area separated from dorsal disc by fold; sculptured with ridges, furrows and bands of microtubercles; cephalic and eighth abdominal setae usually present, first abdominal setae usually absent; vasiform orifice small, subcordate or rounded, normally elevated; operculum subcordate, almost filling vasiform orifice; obscuring the lingula; caudal furrow usually

absent, caudal setae present (Cockerell 1902; Nakahara 1995; Dubey & Ko 2008).

1. *Tetraleurodes thenmozhaiae* Jesudasan and David (Figs 1–4), new record to China

Tetraleurodes thenmozhaiae Jesudasan and David, 1991: 333.



Figure 1. The leaves of host plant *Indocalamus tessellatus* infested by nymphs of *Tetraleurodes thenmozhaiae* Jesudasan and David. A. The leaves of host plant *Indocalamus tessellatus*; B. Puparium of *Tetraleurodes thenmozhaiae*.

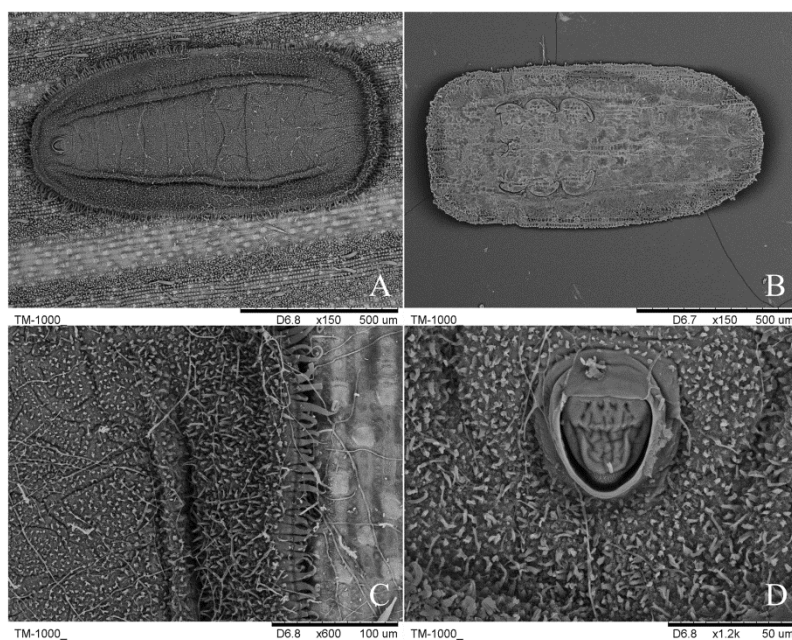


Figure 2. Scanning Electron Microscope (SEM) photographs of *Tetraleurodes thenmozhaiae*. A. Puparium, dorsal view; B. Puparium, ventral view; C. Margin; D. Vasiform orifice and operculum.

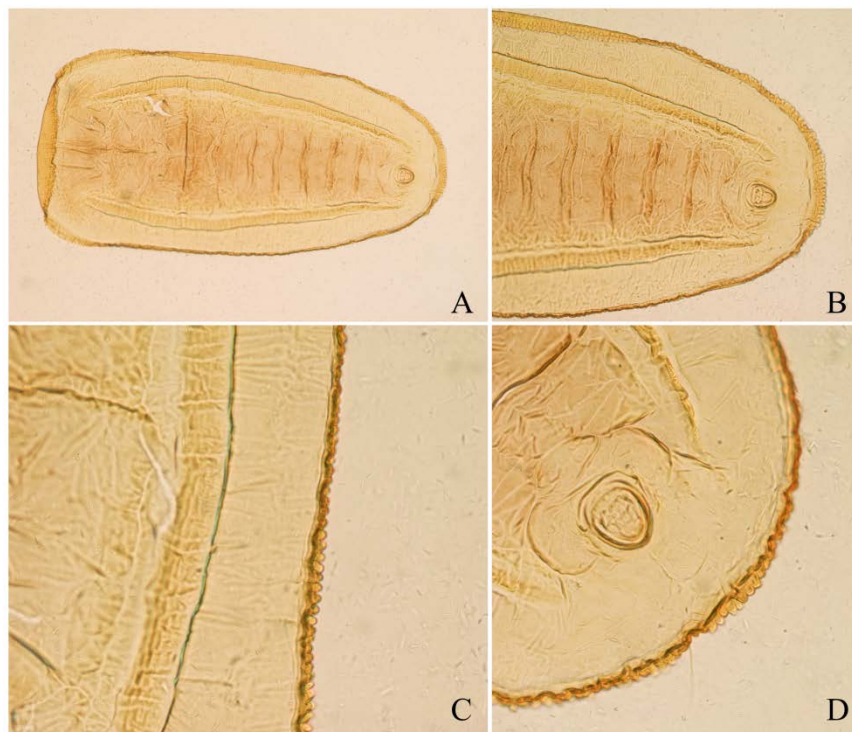


Figure 3. *Tetraleurodes thenmozhaiae*, slide mounted specimen. A. Puparium; B. Abdominal segments; C. Margin; D. Vasiform orifice and operculum.

Puparium. Puparia body transparent creamy colored with a brownish-purple median area; elongate, broadest at the second abdominal segment region, about 1.13 mm in length, 0.57 mm in width. Wax secretions present along the margin, and curved strips of wax secretion distributed along the anterior and posterior submarginal areas.

Margin. Crenulate, 16–18 crenulations in 0.1 mm, each crenulation with a short wax secreting filament at base. Caudal and thoracic tracheal areas not differentiated from margin.

Dorsum. Flat, submargin well-defined, separated from dorsal disc by a submarginal band extending from the level of the cephalic setae to the posterior margin of the seventh abdominal segment, submargin area rather wide, about 65.9–84.5 μm in width, with many irregular lines and striations. Dorsum without granules. Longitudinal molting suture reaching anterior margin and the transverse molting suture reaching the submargin. Thoracic and abdominal segment sutures well-defined, submedian depressions present on abdominal segments II–VII. Submedian depressions occupying about half the length of respective abdominal segment. Pockets of segment VIII present. Median length of abdominal segments I–VIII (A1–A8): A1: 55.4 μm , A2: 57.6 μm , A3: 68.1 μm , A4: 71.8 μm , A5: 71.1 μm , A6: 74.8 μm , A7: 40.3 μm , A8: 38.6 μm . A few small pores present on dorsum. Caudal furrow absent. The distance between posterior margin of vasiform orifice and the puparial caudal margin measures 70.6 μm long, about 1.5x the length of the vasiform orifice.

Vasiform orifice. Elevated posteriorly, cordate to subcircular, slightly longer than wide, about 46.3 μm long, 43.4 μm wide; operculum cordate, 30.2 μm long, 34.4 μm wide, almost filling the orifice. Lingula setose, tip exposed, not extending beyond posterior margin of the orifice.

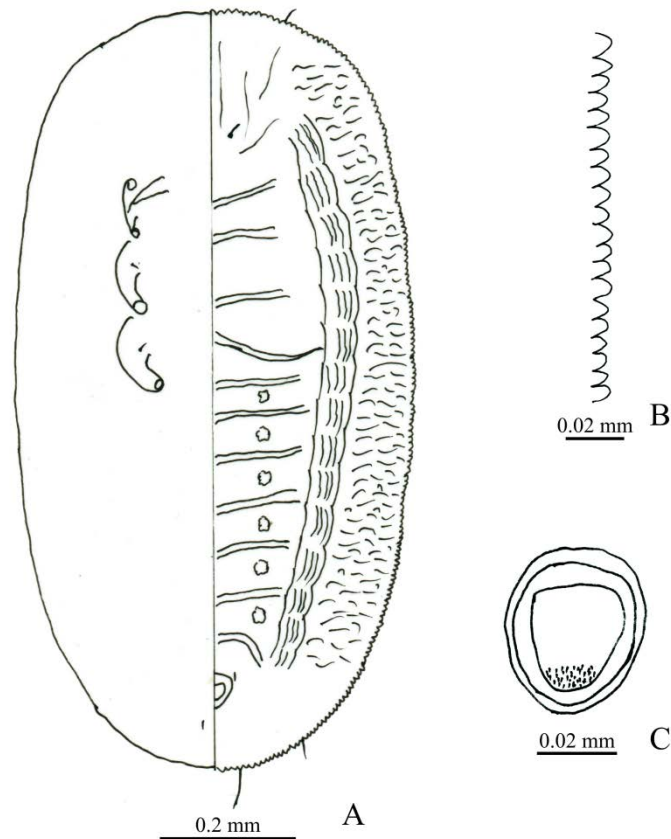


Figure 4. *Tetraleurodes thenmozhaiae*. A. Puparium, dorsal (right) and ventral (left) views; B. Margin; C. Vasiform orifice.

Venter. Thoracic and caudal tracheal folds discernible. A pair of ventral abdominal setae present, finely pointed and $8.2\ \mu\text{m}$ long, $43.6\ \mu\text{m}$ apart. Antennae arising medially to the forecoxae and extending the lateral margin of the prolegs. Microsetae present at base of meso- and metathoracic legs, approximately $2.3\ \mu\text{m}$ long. Adhesive sacs and spiracles present.

Chaetotaxy. Paired anterior and posterior marginal setae $35.3\ \mu\text{m}$ and $24.7\ \mu\text{m}$ long, respectively. Cephalic setae small, pointed, about $6.2\ \mu\text{m}$ long. First abdominal setae absent. Eighth abdominal setae each about $15.6\ \mu\text{m}$ long located lateral to vasiform orifice, located about one fifth of operculum. Caudal setae $51.3\ \mu\text{m}$ long.

Host Plant. Poaceae: *Indocalamus tessellatus* (new record); Lauraceae: *Cinnamomum* sp. (Jesudasan & David 1991).

Distribution. China (Zhejiang); India (Jesudasan & David 1991).

Biology. Specimens were found at a rate of 1–3 per leaf, distributed throughout the under surface of leaves, the body aligned alongside the leaf vein. It was very hard to find the puparia and the population was small. Curved strip wax secretion was present along the anterior and posterior submarginal area of the puparia. There are two other whitefly species co-existing on the same host plant, *Aleurocanthus longispinus* Quaintance & Baker and *Crenidorsum*

multipapillus (Singh). No parasitoids were obtained from the puparia and no ants were observed attending the whiteflies.

Specimens examined. 13 puparia on 12 slides, **China**, Zhejiang, Jiulong Mountain National Nature Reserve, 28°23.32'N, 118°50.44'E, 1 puparium on slide, 27-VIII-2017, leg. Jirui Wang, on *Indocalamus tessellatus*, deposited in ZAFU, Lin'an, China. A few of dry puparia on *Indocalamus tessellatus* leaves with above collection data are available at ZAFU.

Diagnosis. This puparium of this species is characterized by its transparent creamy color with brownish-purple median area. Margin crenulate, each crenulation with a short wax secreting filament at base. Submargin well-defined, separated from dorsal disc by a submarginal band except the anterior and posterior submedian area. Longitudinal molting suture reaching anterior margin and the transverse molting suture reaching the submargin. Submedian depressions present on abdominal segment II–VII. Vasiform orifice cordate, operculum almost filling the orifice. Lingula setose, tip exposed, not extending beyond posterior margin of the orifice.

Remarks. The puparium of *Tetraleurodes thenmozhaiae* resembles that of *T. graminis* in the shape of puparia but differs from it in the color and the absence of a caudal furrow; from *T. champaiensis* Dubey by the way the submargin is separated from the dorsal disc; and from *T. indocalamae* by the submarginal band while *T. champaiensis* by a submarginal raised fold, and by the absence of rhachis-form abdominal segments, not elevated on median area.

2. *Tetraleurodes acaciae* (Quaintance) (Figs 5–7)

Aleurodes acacia Quaintance, 1900: 19.

Tetraleurodes acaciae Quaintance & Baker, 1914: 108.

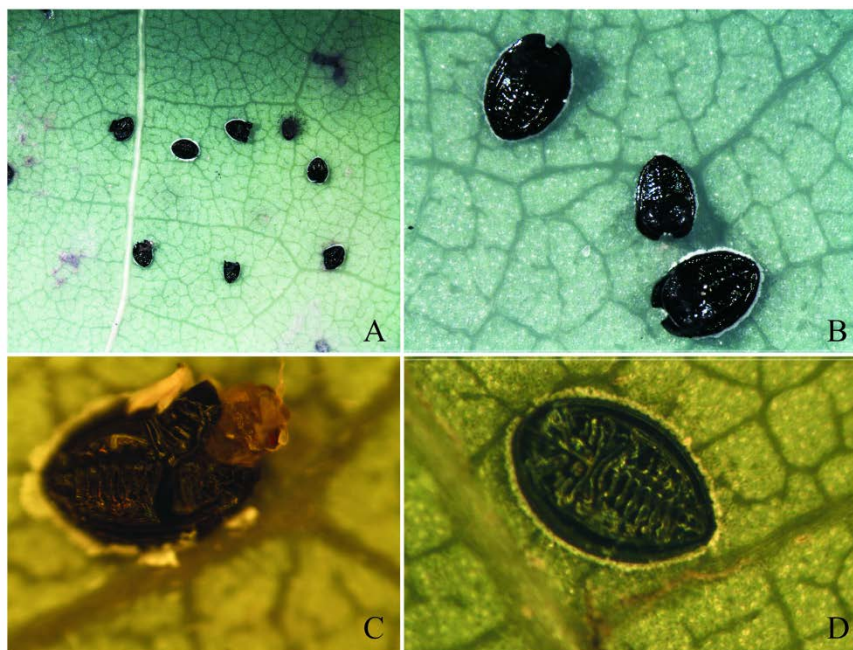


Figure 5. The leaves of host plant *Erythrina variegata* infested by nymphs of *Tetraleurodes acaciae* (Quaintance). A. Numerous of nymphs; B. Empty pupal cases; C. Adult; D. Puparium.

Host Plant. In China, this species was found on *Robinia pseudoacacia*, *Albizia julibrissin*, *Cassia alata*, *Cassia siamea*, *Erythrina variegata*, *Senna surattensis*, all in the family Fabaceae; for records of this species on other hosts worldwide, refer to Mound and Halsey (1978) and Dubey and Ko (2008).

Specimens examined. **China**, Guangdong, South China Agricultural University, 3 puparium on 3 slides, 26-V-2011, leg. Jirui WANG, on *Albizia julibrissin*; 5 puparium on 4 slides, 26-V-2011, leg. Jirui WANG, on *Cassia siamea*; 10 puparium on 6 slides, 26-V-2011, leg. Jirui WANG, on *Erythrina variegata*; 5 puparium on 5 slides, 26-V-2011, leg. Jirui WANG, on *Cassia alata*. Guangdong, Guangzhou Yuexiu Park, 4 puparium on 3 slides, 10-V-2012, leg. Jirui WANG, on *Robinia pseudoacacia*. All the specimens deposited in ZAFU.

Remarks. This species was described from Mexico by Quaintance (1900) on *Acacia* sp. We collected many samples of this species from Guangdong Province on the six species of Fabaceae listed above. Dubey and Ko (2008) recorded this species from Taiwan on *Bauhinia variegata* and *Leucaena glauca*. Martin and Lou (2011) reported this species from Hong Kong on *Erythrina speciosa*, *Leucaena leucocephala*, and an undetermined host from Hainan Island. This species feeds mainly on legumes.

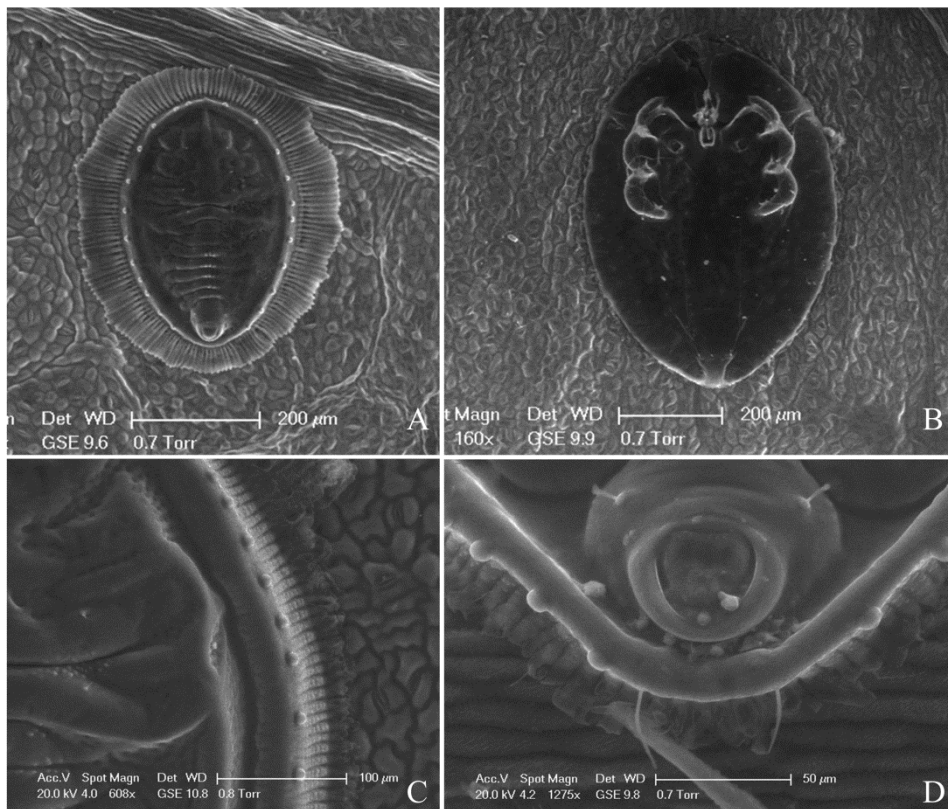


Figure 6. Scanning Electron Microscope (SEM) photographs of *Tetraleurodes acaciae* (Quaintance). A. Uparium, dorsal view; B. Uparium, ventral view; C. Margin; D. Vasiform orifice and operculum.

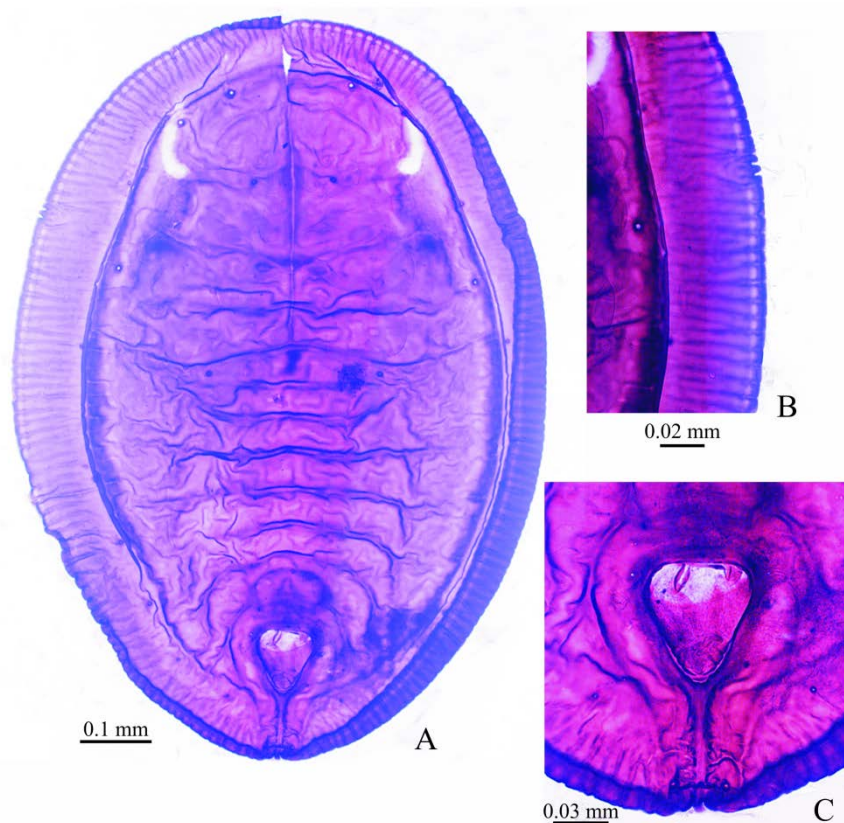


Figure 7. *Tetraleurodes acaciae* (Quaintance), slide mounted specimen. A. Puparium; B. Margin; C. Abdominal segments, vasiform orifice and operculum.

3. *Tetraleurodes neemani* Bink-Moenen

Tetraleurodes neemani Bink-Moenen & Gerling, 1992: 34.

Specimens examined. 2 puparia on 2 slides, **China**, Guangdong, South China Agricultural University, 26-V-2011, leg. Jirui WANG, from *Carmona microphylla*, deposited in ZAFU.

Distribution. China (Guangdong); Cyprus; Iran; Israel; Lebanon; Rhodes; Syria; Turkey (Bink-Moenen 1992; Martin *et al.* 2000).

Host plants. *Carmona microphylla* (Wang *et al.* 2016), *Laurus nobilis* (Bink-Moenen 1992).

Remarks. This species resembles *T. hederæ* Goux, but can be distinguished by the smaller puparium. Wang *et al.* (2016) reported this species from Guangdong on *Carmona microphylla* based on only 2 puparia on 2 slides in the ZAFU.

4. *Tetraleurodes graminis* Takahashi (Fig. 8)

Tetraleurodes graminis Takahashi, 1934: 67.

Specimens examined. 10 puparia on 1 slide, **China**, Taiwan, 28-IX-2003, leg. Juncheng KO, from Poaceae, deposited in National Taiwan University.

Host Plant. Poaceae: *Imperata* sp. (Takahashi 1934).

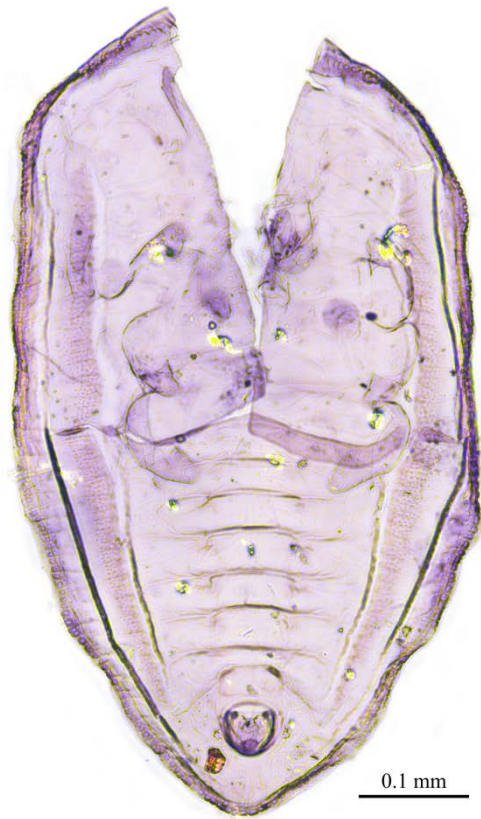


Figure 8. *Tetraleurodes graminis* Takahashi, slide mounted specimen.

Remarks. Takahashi (1934) described this species from Taiwan on *Imperata* sp. and deposited syntypes in the Taiwan Agricultural Research Institute (TARI). Dubey and Ko (2008) redescribed this species in much detail. Martin collected it on the blade of an undetermined grass from Hong Kong in 1979, with a single sample of just three specimens in the Natural History Museum (NHM), in London, UK.

5. *Tetraleurodes oplismeni* Takahashi

Tetraleurodes oplismeni: Takahashi, 1934: 66.

Host Plant. Poaceae: *Enteropogon dolichostachys* (Dubey & Ko 2008), *Imperata* sp. (Takahashi 1934).

Remarks. Takahashi (1934) described this species on *Oplismenus* sp. In Taiwan and deposited syntypes in the TARI. Dubey and Ko (2008) redescribed this species and added *Enteropogon dolichostachys* as a new host plant record.

Key to the puparia of *Tetraleurodes* species known to occur in China

1. Puparia black 2
- Puparia pale white or yellowish 3
2. Puparia shining black, shape subelliptical, the gland tubercles present along the marginal rim, median tubercles on abdominal segments present *acaciae* (Quaintance)

- Puparia black, shape elongate, about twice as long as wide; the gland tubercle absent along the marginal rim, subdorsum with some minute tubercles; median tubercle on abdominal segments absent *graminis* Takahashi
- 3. Cephalothorax with 2 pairs of long setae on the median area *oplismeni* Takahashi
- Cephalic setae small 4
- 4. Puparia about 1.13 mm in length, 0.57 mm in width; body transparent creamy colored with a brownish-purple median area, short wax secretions present along the margin, submedian depressions present on abdominal segment II–VII *thenmozhaie* Jesudasan and David
- Puparia about 0.85 mm in length, 0.63 mm in width; body yellowish, surrounded by fringe of long wax-hairs, submedian depressions faint *neemani* Bink-Moenen

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